

CLAIMS

What is claimed is:

- 1 1. An apparatus for determining azimuth of a remote formation boundary by in a
2 logging while drilling tool by measuring a transverse magnetic field in a down
3 hole tool comprising:
4 a downhole resistivity tool for traversing a well bore measuring a property of
5 interest in a formation adjacent to the well bore, the down hole tool having a body
6 with a longitudinal axis substantially aligned with a longitudinal axis of the well
7 bore, the body having a external surface;
8 a coil antenna placed near the external surface of the tool body;
9 a groove cut in the external surface tool body and oriented horizontally with
10 respect to the longitudinal axis of the tool body;
11 a transmitter comprising a transverse coil placed in the grooves for transmission
12 or reception of a transverse magnetic field; and
13 a receiver coil antenna near the external surface of the tool body for reception of a
14 magnetic field which is oriented substantially orthogonal with respect to the
15 transmitter; and
16 grooves cut in the external surface of the tool body and oriented substantially
17 perpendicularly with respect to the antenna wire.

1 2. The apparatus of claim 2, further comprising:
2 a gap between the transverse coil and a bottom each groove in the plurality of
3 grooves; and
4 a ferrite material placed in the gap.

1 3. The apparatus of claim 1 further comprising:
2 a plurality of receivers; and
3 a plurality of transmitters.

1 4. The apparatus of claim 1, wherein the measurement further comprises:
2 an in phase and a quadrature component.

1 5. The apparatus of claim 1, wherein the groove measurement further
2 comprises:
3 a plurality of grooves.

1 6. The apparatus of claim 1, further comprising:
2 a gap between the coil and the bottom of each groove under both transmitter and
3 receiver coils; and a ferrite material placed in the gap.

1 7. The apparatus of claim 1, wherein the groove further comprises:
2 a flat shape at a bottom of the groove.

1 8. The apparatus of claim 1, wherein the groove further comprises:

2 a curved shape at a bottom of the groove.

1 9. A method for determining azimuth of a remote boundary by in a logging while
2 drilling tool by measuring a transverse magnetic field in a down hole tool
3 comprising:

4 measuring a property of interest in a formation adjacent the well bore, while
5 traversing a well bore with a down hole tool, the down hole tool having a body
6 with a longitudinal axis substantially aligned with a longitudinal axis of the well
7 bore, the body having a external surface;

8 orienting horizontally with respect to the longitudinal axis of the tool body a
9 groove cut in the external surface tool body and; and

10 placing a transmitter comprising a transverse coil placed in the grooves for
11 transmission or reception of a transverse magnetic field; and

12 receiving a magnetic field in a receiver oriented orthogonal with respect to the
13 transmitter.

1 10. The method of claim 9, further comprising:

2 measuring a magnetic field with a single or plurality of receivers and a single or
3 plurality of transmitters that are arranged substantially orthogonal with respect to
4 the receiver(s);

5 providing a gap between the transverse coil and a bottom each groove in the
6 plurality of grooves; and
7 placing a ferrite material placed in the gap.

1 11. The method of claim 9 further comprising:
2 providing a plurality of receivers; and
3 providing a plurality of transmitters.

1 12. The method of claim 9, further comprising:
2 measuring an in- phase and quadrature components of a magnetic field.

1 13. The method of claim 9, further comprising:
2 processing the magnetic field data downhole from a plurality of receivers; and
3 processing the magnetic field data downhole from a plurality of transmitters; and
4 processing the magnetic field data downhole from a plurality of frequencies.

1 14. The method of claim 13, further comprising:
2 measuring the magnetic field at multiple tool azimuthal angles.

1 15. The method of claim 9, further comprising:
2 transmitting the measured and downhole-processed data uphole via a downhole
3 data telemetry system;
4 measuring at a first frequency; and
5 measuring at a second frequency.

1 16. The method of claim 8, wherein the groove further comprises:
2 providing a flat shape at a bottom of the groove.

1 17. The method of claim 9, wherein the groove further comprises:
2 providing a curve shape at a bottom of the groove.

1 18. The method of claim 9, further comprising:
2 processing the magnetic field data from a formation;
3 providing a plurality of receivers to reject tool- and borehole-related artifacts
4 including but not limited to tool bending and tool eccentricity effects;
5 processing the magnetic field data from a plurality of transmitters to reject tool-
6 and borehole-related artifacts including but not limited to borehole rugosity
7 effects; and
8 processing the magnetic field data from a plurality of frequencies.

1 19. A computer readable medium containing instructions that when executed by a
2 computer perform a method for determining azimuth of a remote boundary by a
3 measured amplitude or phase component of an amplitude and phase component in
4 a logging while drilling tool by measuring a cross-component transverse magnetic
5 field in a down hole tool comprising:
6 measuring a property of interest in a formation adjacent the well bore, while
7 traversing a well bore with a down hole tool, the down hole tool having a body
8 with a longitudinal axis substantially aligned with a longitudinal axis of the well
9 bore, the body having a external surface;
10 orienting horizontally with respect to the longitudinal axis of the tool body a
11 groove cut in the external surface tool body and; and
12 placing a transmitter comprising a transverse coil placed in the grooves for
13 transmission or reception of a transverse magnetic field; and
14 receiving a magnetic field in a receiver oriented orthogonal with respect to the
15 transmitter.

1 20. The medium of claim 19 further comprising:
2 providing a gap between the transverse coil and a bottom each groove in the
3 plurality of grooves; and
4 placing a ferrite material placed in the gap.

1 21. The medium of claim 19 further comprising:

2 providing a plurality of receivers; and
3 providing a plurality of transmitters.

1 22. The medium of claim 19, further comprising:
2 measuring an in phase and quadrature component.

1 23. The medium of claim 19, further comprising:
2 measuring at a first frequency; and
3 measuring at a second frequency.

1 24. The method of claim 19, wherein the groove further comprises:
2 providing a flat shape at a bottom of the groove.

1 25. The apparatus of claim 19, wherein the groove further comprises:
2 providing a curve shape at a bottom of the groove.

1 26. The method of claim 19, further comprising:
2 providing a plurality of grooves.